HEAT INTEGRATION ANALYSIS OF GAS TO LIQUID (GTL) PROCESS

MOHD FUAD BIN CHE NORDIN

Submitted to the Faculty of Chemical & Natural Resources Engineering in partial fulfillment of the requirements for degree of Bachelor of Chemical Engineering (Gas Technology)

Faculty of Chemical and Natural Resources Engineering
University Malaysia Pahang (UMP)

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ABSTRACT

Gas-to-liquid (GTL) process involves the chemical conversion of natural gas (or other gas sources) into synthetic crude that can be upgraded and separated into different useful hydrocarbon fractions including liquid transportation fuels. A leading GTL technology is the Fischer Tropsch process. The objective of this work is to provide a techno-economic analysis of heat intergrated GTL flowsheet. First, a base case GTL flowsheet from published result is modeled using Aspen Hysys to determine the energy flows, performance criteria, and equipment specifications. Next, heat integration studies by Pinch Analysis are performed to address the heating and cooling utilities. After the integration, 100% of heating duty requirement can be saved, and the cooling duty requirement can be saved for about 23%. Finally, an economic analysis is undertaken to determine the energy costing of the GTL flowsheet. It shows, RM171.76 MM/year and RM 0.63 MM/year can be saved from heat utility and cooling utiliy respectively. Finally this research has provided a framework for analyzing and improving the performance of FT-GTL plants. The following tasks have been performed, typical GTL process has been synthesized, thermal pinch analysis has been applied to get the optimum heating and cooling utilities and Aspen Hysys have been used in evaluating the performance and cost of the process. The following recommendations are suggested for future work, Strategies to reduce greenhouse gas (GHG) emissions from the GTL plant, address mass exchange network (MEN) and scale up strategies and analysis should be carried out.

ABSTRAK

Gas-ke-cecair (GTL) melibatkan proses penukaran kimia gas bumi (atau sumber-sumber-sumber gas yang lain) ke dalam mentah sintetik yang boleh dipertingkatkan dan dipisahkan ke dalam pelbagai pecahan hidrokarbon kepada termasuk pengangkutan bahan bakar cair. Teknologi GTL terkemuka adalah proses Fischer Tropsch. Tujuan kajian ini adalah untuk memberikan analisis tekno-ekonomi dari flowsheet GTL terintegrasi. Pertama, kes dasar GTL flowsheet dari hasil diterbitkan dimodelkan menggunakan Aspen Hysys untuk menentukan aliran tenaga, kriteria prestasi, dan spesifikasi peralatan. Selanjutnya, kajian integrasi tenaga dengan Pinch Analisis dilakukan untuk menangani utiliti pemanasan dan pendinginan. Setelah integrasi, 100% dari pemanasan keperluan tugas boleh dijimatkan, dan keperluan tugas pendingin boleh dijimatkan sekitar 23%. Akhirnya, analisis ekonomi dilakukan untuk menentukan kos tenaga dari flowsheet GTL. Kajian ini menunjukkan, RM171.76 MM / tahun dan RM 0,63 MM / tahun boleh diselamatkan masing-masing dari utiliti utiliy pemanasan dan pendinginan. Akhirnya kajian ini telah menyediakan rangka kerja untuk menganalisis dan meningkatkan prestasi loji proses FT-GTL. Tugas-tugas berikut telah dilakukan, proses GTL khas telah disintesis, pinc analisis telah dilaksanakan untuk mendapatkan penggunan tenaga yang optimum dan utiliti pendinginan dan Aspen Hysys telah digunakan dalam menilai prestasi dan kos proses. Cadangan berikut disarankan untuk pekerjaan di masa depan, Strategi untuk mengurangkan gas rumah hijau (GHG) dari loji proses GTL, rangkaian pertukaran material (MEN) dan meningkatkan strategi dan analisis harus dilakukan.

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LNG	-	Liquid Natural Gas
H_2	-	Hydrogen
N_2	-	Nitrogen
O_2	-	Oxygen
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CO_2	-	Carbon Dioxide
H_2O	-	Water
LPG	-	Liquefied Petroleum Gas
F-T	-	Fischer Tropsch
BSCFD	-	Set Billion Standard Cubic Feet Per Day
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POX	-	Partial Oxidation
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ATR	-	Autothermal Reforming
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TID	-	Temperature-Interval Diagram
TEHL	-	Table of Exchangeable Heat Loads

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I declare that this thesis entitled '**Heat Integration Analysis Of Gas To Liquid (GTL) Process**' is the results of my own research except as cited in the references. The thesis has not been accepted for any degree and is not concurrently submitted candidature of any degree.

Signature : .....

Name : MOHD FUAD BIN CHE NORDIN

Date : 1th MARCH 2011

Special Dedication to my beloved parents, siblings and all my friends for their love and encouragement.

And,

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ABSTRACT

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SIMULATION AND HEAT INTEGRATION ANALYSIS OF GAS TO LIQUID PROCESS

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Abstract

Gas-to-liquid (GTL) process involves the chemical conversion of natural gas (or other gas sources) into synthetic crude that can be upgraded and separated into different useful hydrocarbon fractions including liquid transportation fuels. A leading GTL technology is the Fischer Tropsch process. The objective of this work is to provide a optimization and heat integration for cost saving and reduction of energy usage. First, a base case flowsheet is synthesized to include the key processing steps of the plant. Then, computer-aided process simulation (Aspen Hysys V7.0) is carried out to determine the energy flows, performance criteria, and equipment specifications. Next, heat integration studies by Pinch Analysis are performed to address the heating and cooling utilities. From analysis, 100% energy (6.994E+05KW) heating utilities is saved while 23% energy (7.00E+5KW) for cooling utilities. Finally, an economic analysis is undertaken to determine the energy saving of the plant. After heat integration, 50.52MM$/year and 0.185 MM$/year is saved from heat utility and cooling utiliy respectively.

Keyword: Simulation,Intergration,Optimization,GTL

1. Introduction

Natural gas is recognized as one of the cleanest and most abundant fossil fuels. With the growing global market for natural gas, it is important to identify effective methods for use worlwide energy resource. In many cases, there is an economic incentive to ship the gas in liquid form which occupies much less volume than the gaseous form. In this regards two main approaches have been adopted: liquefaction leading to liquefied natural gas (LNG) and chemical conversion to convert gas to liquid (GTL). The key concept of a GTL process is to chemically convert the gas to longer-chain hydrocarbons that will typically be in the range of liquid transportation fuels.

The GTL process is mainly comprised of three steps shown in Fig. 1.1. These are steam reforming of natural gas to produce syngas (CO and H2), followed by F-T reaction, and finally upgrading of the products to cracking and hydro-processing units for the synthesis liquid hydrocarbons to yield products that meet the market specifications.

There are many design variables that complicate the F-T synthesis step *(Steynberg and Dry, 2004).* One of these is the catalyst since it will undergo changes during the reaction due to interaction with chemical species. The reactor performance is another important element. The gas velocity and the conversion rate can all be affected by the reactor diameter and height, as well as how the cooling system is installed.

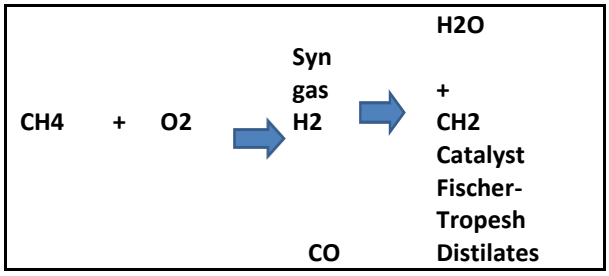

Figure 1.1: GTL process in chemistry

The process involves three steps: reforming, F-T reaction, and upgrading. First, natural gas is preheated and sent into an autothermal reactor to react with steam and oxygen. The temperature of the syngas from the reactor is too high to be fed into the F-T reactor. Therefore, the syngas stream is cooled down and water is separated out.